It would, I think, be interesting to determine, on the more transparent portions of glacier ice, by the simple and easily applied test of polarized light, whether a definite crystalline structure prevail in its interior, and if so, in what direction the axis lies in relation to the lines of fissure in the crevasses. Nor is there any reason why the idea above thrown out respecting the mutual modification of structure of two masses cemented by regelation, at or near their plane of junction, should not be subjected to a similar test.

XX. "On the Absorption and Radiation of Heat by Gaseous and Liquid Matter."—Fourth Memoir. By JOHN TYNDALL, F.R.S. Received June 18, 1863.

In his former researches on the absorption and radiation of heat by gaseous matter, the author compared different gases and vapours at a common thickness with each other. In the first part of the present communication he determines, in the case of several gases and vapours, the absorption effected by different thicknesses of the same gaseous body. His least thickness was 0·01 of an inch, and his greatest 49·4 inches; thus the thickness varied from 1 to nearly 5000. The apparatus employed for the smaller thicknesses consisted of a hollow cylinder, with its end closed by a plate of rock-salt; into this fitted a second hollow cylinder, with its end closed by a second plate of salt. One cylinder moved within the other as a piston, and by this means the plates of salt could be brought into flat contact with each other, or separated to any required distance. The distance between the plates was measured by means of a vernier. The cylinder was placed horizontal, being suitably connected with the front chamber used in the author's former researches, and the source of heat employed was a copper plate, against which a steady sheet of gas-flame was caused to play.

The absorptions of carbonic oxide, carbonic acid, nitrous oxide, and olefiant gas were determined by this apparatus, and such differences as might be anticipated from former experiments were found. Olefiant gas maintained its great supremacy over the others at all thicknesses. A layer of this gas, 0·01 of an inch thick, effected an absorption of about 1 per cent. of the total radiation. To show

the competence of the apparatus to measure an absorption of this magnitude, it is only necessary to state that the galvanometric deflection corresponding to this absorption was 11 degrees. Were it worth while, it might be shown that the absorption by a plate of the gas not more than $\frac{1}{1000}$th of an inch in thickness is capable of measurement. A layer of olefiant gas 2 inches in thickness intercepted nearly 30 per cent. of the entire radiation. Such a layer, encompassing the earth as a shell, permitting the passage of the solar rays, and preventing the escape of the terrestrial ones, would probably raise the surface of the earth to a stifling temperature. A layer of the gas three-tenths of an inch in thickness intercepts 11·5 per cent. of the radiation. Such a layer, if diffused through 10 feet of air, would be far more attenuated than the aqueous vapour actually existing in the air; still it would effect an absorption greater than that which the author has ascribed to the atmospheric vapour within 10 feet of the earth's surface. In the presence of such facts, arguments drawn from the smallness of quantity of the atmospheric vapours are entirely devoid of weight.

For larger thicknesses of gas and vapour, a tube was employed, which was divided into parts capable of being used separately or together. The mode of proceeding was this:—A brass cylinder 49·4 inches long had its two ends stopped with rock-salt; a source of heat was attached to it exactly as in the author's experiments described in former memoirs. The pile and the compensating cube also occupied their old positions; but instead of determining the absorption effected in a column of gas or vapour equal in length to the whole tube, the tube was now divided into two independent compartments by a third plate of rock-salt. Let us call the compartment furthest from the pile the first chamber, and that nearest to the pile the second chamber. The experiments were commenced with the first chamber very short, and the second chamber long; and the plate of salt was subsequently shifted so as to lengthen the first chamber and shorten the second one, the sum of the lengths of both chambers being preserved constant at 49·4 inches.

The absorption effected in the first chamber acting alone was first determined; then the absorption effected by the second chamber acting alone; and finally, the absorption effected when both chambers were occupied by the gas or vapour was determined. This arrange-

ment enabled the author to examine the influence of the *sifting* which occurred in the first chamber on the absorption effected by the second one. The thermal coloration of the various gases was rendered very manifest by these experiments—the heterogeneity of the obscure calorific flux being demonstrated, and the selective action of the gases on particular constituents of the flux exhibited. A stratum of carbonic oxide 8 inches thick being placed in front of a tube containing 41·4 inches of the same gas, those 8 inches intercept 6·02 per cent. of the whole radiation; the same 8 inches being placed *behind* the column 41·4 inches in length, the absorption effected is almost *nil.* So with carbonic acid: 8 inches in front absorb 6·25 per cent., while behind they absorb a scarcely measurable quantity. Similar remarks apply to the other gases, the reason manifestly being, that when the 8-inch stratum is in front, it intercepts the main portion of the rays which give it its thermal colour, while when it is *behind,* these rays have been in great part withdrawn, and to the remainder the gas is transparent.

From analogous reasoning we conclude that the sum of the absorptions of the two chambers, taken separately, must always be greater than the absorption effected by a single column of gas of a length equal to the sum of the two chambers. This conclusion is illustrated in a striking manner by the results; and it is further found that if the mean of the sums of the absorptions of the two chambers, taken separately, be divided by the absorption of the sum, the quotient is the same for all gases. It is also to be inferred from the foregoing considerations, that the sum of the absorptions must diminish as the two chambers become more unequal in length, and must be a maximum when they are equal.

In these days a special interest attaches to the radiation from any gas through itself, or through any other having the same period of radiation. The author records the results of an elaborate series of experiments on this point. The experimental tube, 49·4 inches long, was divided into two compartments by a partition of rock-salt. The compartment nearest to the pile was filled with the gas which was to act as absorber, while the chamber most distant from the pile contained the gas which was to act as radiator. This latter gas was warmed by the destruction of its own *vis viva* within the chamber. The radiation was what the author has called dynamic radiation.

The lengths of two chambers were varied, the radiating column being lengthened, and the absorbing one shortened at the same time. The experiments were carried out with a considerable number of gases and vapours.

The experiments with the vapours were thus executed. First, the chamber nearest the pile was occupied by vapour of a certain pressure; the other chamber was then occupied by the same vapour at the same pressure. The entrance of the vapour was so slow, and its quantity was so small, that the dynamic radiation due to the destruction of its own *vis viva* was almost insensible. The needle being at zero, dry air was allowed to enter the chamber most distant from the pile; the air became heated, communicated its heat to the vapour, and the latter radiated it against the pile. It is quite evident that not only does this case resemble, but it is of the same mechanical nature as that in which a vibrating tuning-fork is brought into contact with a surface of some extent. The fork, which a moment before was inaudible, becomes at once a copious source of sound; it communicates its motion to a body of sufficient dimensions to transmit it in large quantities to the air. What the sounding-board is to the tuning-fork, the vibrating compound molecule is to the elementary atom. The tuning-fork swinging alone is in the condition of the elementary atom radiating alone, the sound of the one and the heat of the other being insensible; but in association with the particles of acetic or sulphuric ether, the elementary atom is in the condition of the tuning-fork applied to its sound-board, communicating through the molecule motion to the luminiferous ether, as the fork through the board communicates it to the air.

These experiments show the great opacity of a gas to radiations from the same gas. They also show, in a very interesting manner, the influence of attenuation in the case of the vapours. The individual molecules of a vapour may be powerful absorbers and radiators, but in thin strata they may constitute an open sieve, through which a large quantity of radiant heat may pass. In such thin strata, therefore, the vapours, as used in the experiments, were generally found less energetic than the gases, while in thick strata the same vapours showed an energy greatly superior to the same gases.

A few striking results are recorded by the author in illustration of

the influence of a lining within the experimental tube on the radiation. A ring of blackened paper, for example, not more than $1\frac{1}{2}$ inch in width, placed within a polished brass tube, radiated, when dry air was permitted to enter the tube, a quantity of heat sufficient to urge the needle of the galvanometer through an arc of 56°; while, when the ring was removed, the radiation from the whole surface of the tube produced a deflection of only 7°·5.

The author finally examines the diathermancy of the liquids from which the vapours made use of in his experiments were derived; and the result leaves no shadow of doubt upon the mind, that if any vapour be a strong absorber, the liquid of that vapour is also a strong absorber. The phenomenon is one in which the individual molecules are implicated, the molecule carrying its power as a radiant and an absorbent through all its states of aggregation. The order of absorption in liquids and vapours is precisely the same. These facts revive thoughts regarding the connexion between radiation and conduction, to which the author has already given expression. In a future memoir he hopes to throw additional light on this important subject.

XXI. "Account of Observations of Atmospheric Electricity taken at Windsor, Nova Scotia." By Joseph D. Everett, M.A., F.R.S.E., Professor of Mathematics, &c. in King's College, Nova Scotia. Communicated by Professor William Thomson. Received June 18, 1863.

1. The observations here described were taken at my house, which is on the College hill, Windsor, in latitude 44° 58′ 34″ N., and longitude 64° 8′ 30″ E. They were taken at a landing-window looking N.E., whose sill is 27 feet above the ground. There is a very clear view from the window, and no trees, buildings, or other obstacles to screen it from the full effect of atmospheric electricity. The ground slopes away on the N.E., E., S.E., and S., and is nearly level in other directions, rising slightly, however, for the first 20 yards on the N.W. The surrounding country is undulating, with the exception of a stretch of flat alluvial soil which runs past the base of the College hill, and to which the ground slopes away from